U.S. DEPARTMENT OF AGRICULTURE • FOREST SERVICE • FOREST PRODUCTS LABORATORY • MADISON, WIS.
In Cooperation with the University of Wisconsin

U. S. FOREST SERVICE
RESEARCH NOTE
FPL-0122
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PANELING AND FLOORING FROM LOW-GRADE HARDWOOD LOGS

Summary

From small, low-grade hardwood logs, the Forest Products Laboratory has developed an experimental wall paneling that is equally suitable for flooring. Short cutoffs of the panel material can also be utilized as parquet block flooring, Highlights of the system, which includes packaging the material in standard-size bundles, are:

(1) Small, low-grade logs are used exclusively, partly because of the greater number of character marks which occur in these logs, partly because of the universal availability of this type of log, and partly because of the low initial cost.

(2) Instead of manufacturing logs into standard lumber and resawing to make paneling, the logs are broken down at the headsaw to near the thickness of the finished product.

(3) Both conventional kiln drying and press drying schedules were used for the thin unedged boards, which for this study were surfaced before drying. Press drying between heated platens reduces width shrinkage during drying, and the finished product shrinks and swells only about three-fourths as much as kiln-dried boards. Press drying of oak also produces a color about the shade of chestnut or light walnut and accentuates the character marks.

(4) Face widths of the pieces of panel are 2, 3, 4, and 6 inches, and the lengths are 2, 4, 6, and 8 feet. Each layer in a bundle of paneling is 6 inches wide by 8 feet long so that wall or floor coverage is 4 square feet per layer and 32 square feet per bundle. Nominal size and matched size are the same and no allowance is necessary in calculating square feet of coverage as it is with strip flooring for instance.

(5) Inatallation of the side- and end-matched panels is simple, and only a few carpenter's tools are required. One of the most important installation features is that the pieces in each layer of a bundle should be used in the same arrange-ment as they are in the layers. Also, a complete layer should. be used before skarting an the next layer.

(6) So many combinations of pieces are possible that they create a completely random appearance in a finished wall of any size. At the same time, installation is easily accomplished around heat-duct openings, electrical outlets, doors, windows, and other wall features.

PANELING AND FLOORING FROM LOW-GRADE HARDWOOD LOGS

By

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Introduction

The forests of the Northeast, North Central, and Appalachian regions of the United States contain a vast supply of low-quality hardwood timber, During the past decade, the Forest Products Laboratory has suggested several types of experimental paneling and flooring as a market for this low-quality material.

These products must have wide market possibilities, be easy to ship, and be designed to utilize machines and labor in or near the area in which the timber resources occur. If possible, the products should be precut and prefinished. They must also be of such a nature that manufacturers will take advantage of new processing techniques, eliminate costly steps in production, and provide a unique appearance by utilizing the "character marks" which occur in products from such low-quality logs.

To expedite the work of producing paneling and flooring from the abundantly available low-grade logs, the Laboratory conceived the idea of going directly from the logs to the products. This is in contrast to the usual plan of first sawing lumber that must be resawed into the product.

This flooring and paneling was produced at the FPL by using the equipment on hand to simulate the processes which would be employed in commercial production.

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[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

Figure 1.--Red oak logs used in this study.

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Types of Logs

The red oak logs (fig. 1) from which FPL product development specialists made the paneling were of the type usually found in a railroad crosstie, or pallet and blocking mill. One-half of the 12 logs that were selected were lower grade factory logs, and the other six logs would not qualify as factory grade. They averaged 10 inches in diameter and 100 inches long.

Manufacturing Procedures

Most of the 12 logs were sawed on the FPL sawmill, simulating a sash-gang operation; therefore, there was no attempt to saw for grade. Two or three logs were split approximately in the center on the head rig; an attempt was made to saw these half-round pieces (with the flat face towards the fence) to 5/8-inch thickness on the resaw. This procedure was an attempt to save material, as the resaw removes a kerf about 1/8 inch wide, whereas the headsaw removes slightly less than 5/16 inch in the saw kerf. Due to faulty performance of the resaw, the thickness was not sufficiently uniform; therefore, the remainder of the logs were sawn directly on the head rig.

As the unedged boards were removed from the saw, they were barked, using a draw shave, and sorted into two groups. One group was dried by a conventional method involving forced-air and kiln drying, and the other group dried in the hot press, using ventilated cauls. The green boards to be kiln dried were surfaced on one side to slightly under 5/8 inch, to bring all boards to roughly the same thickness. The boards for press drying were surfaced on one or, in some cases, on two sides to 0.600 inch while in the green condition. The combination of the forced-air and kiln-drying schedules required an overall period of 13-1/2 days to dry and condition the material to approximately 7 percent moisture content. Details of this operation are presented in Appendix A.

The conditions of press drying the hardwood boards of this thickness and length varied over a wide range and are summarized in Appendix B. The ventilated cauls and screens used in this process are shown in figure 2. The press-drying schedule which appeared to give the beat results in this exploratory work was 55 minutes in the press at a temperature of 350° F. and a pressure of 50 pounds per square inch. This schedule overdries the material (to a moisture content of 1 to 3 percent) and also somewhat darkens the wood. The darkening is not uniform and therefore changes the appearance of the oak considerably, making it resemble chestnut or sometimes walnut. The extractives from certain

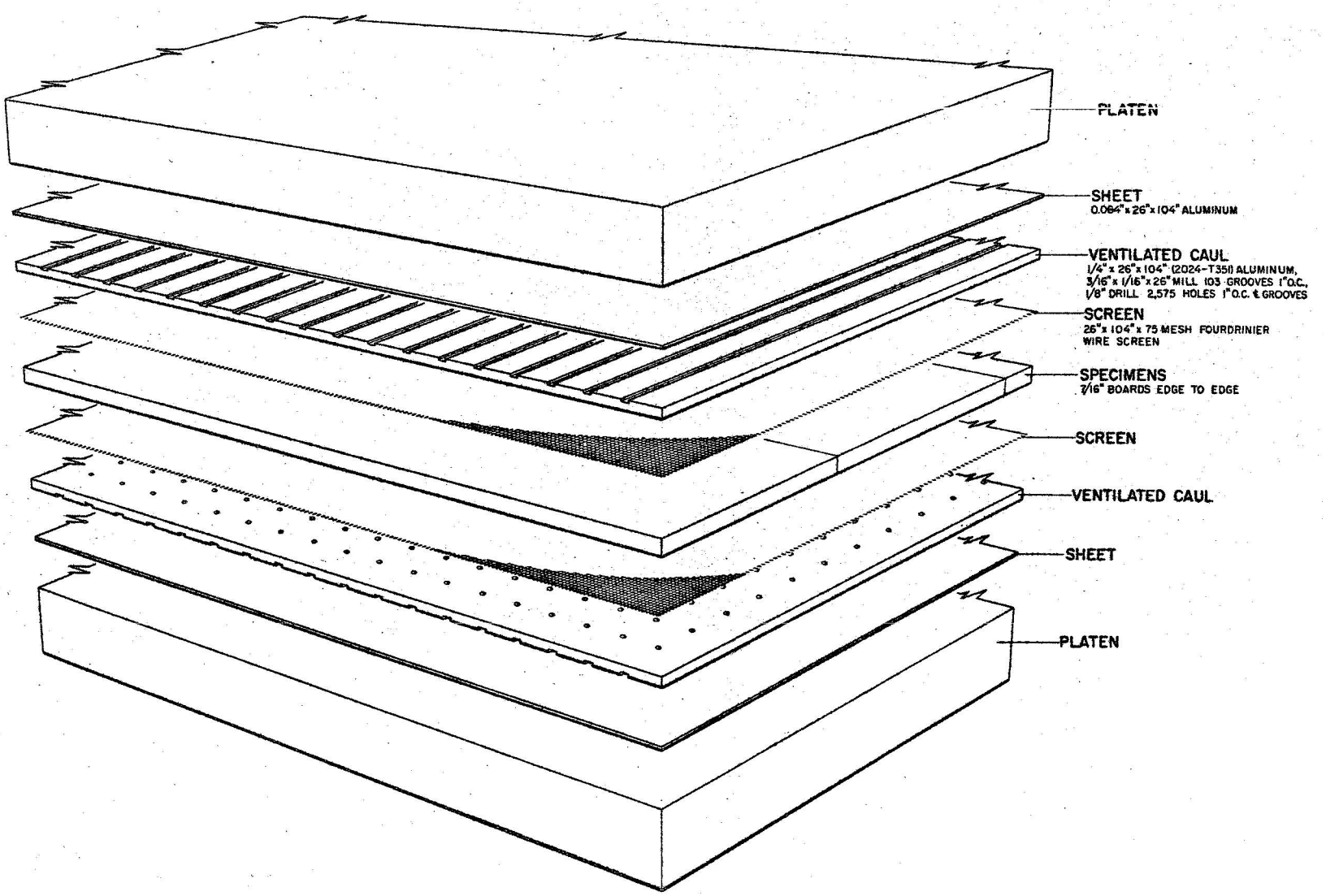

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Figure 2.--Details of ventilation cauls and screens in press drying.

portions of the boards, particularly at those spots having short grain, considerably darken the surface of the rough boards. It was found, however, that this surface darkening could be removed with a very light planing or sanding operation. In general, the press-dried boards were much flatter and somewhat thinner than the kiln-dried boards.

After all boards had come to approximate equilibrium (about 6 to 7 percent moisture content for kiln-dried and 5 percent for press-dried) in the workroom, they were planed to the final thickness of 7/16 inch. The planing operation was conducted in three passes through a single-head cabinet planer. In the final pass, the better of the two sides was chosen as the face side. Some of the kiln-dried boards were cupped, and in a few cases these cupped boards split (sometimes from end to end) when passing through the planer. The press-dried material, being exceedingly flat, presented no problem with splitting.

Templates of 1/8-inch-thick hardboard were made to the rough size of each combination of width and length of paneling and used in marking out the boards for cutting. Each board was carefully studied, and the templates positioned to obtain maximum yield of wide and long material. Ripping cuts were made first, and in most cases secondary ripping cuts were made to yield the two widths of strips for the block flooring. Each paneling size was marked on the face of the boards with the flooring pieces marked by an "F." At first 16-inch modules were used because of customary 16-inch spacing of studs; later in the development period it was decided that muliples of 24 inches were superior.

The designated pieces were cut from each board and machined to the pattern based on conventional fractional dimensions (fig. 3). A slightly thinner paneling was designed later, with dimensions expressed in decimals (fig. 4). The face side of each piece was sanded in a two-drum traveling-bed sander to complete the machining operation. The flooring pieces were machined and assembled into flooring blocks of the type shown in figure 5, with the splines being obtained from the edgings from the ripping operation.

Packaging is the key operation in producing paneling by this concept of going directly from the log, through unedged boards, to multiple-width paneling. The various-size pieces are assembled in this operation in the desired randomized pattern. This is a job which, in production, probably would involve a mechanized sorting and packaging or wrapping procedure, along with a conveyor-belt system to deliver the material to the packaging stations. This operation is simulated in figure 6 which shows, from left to right, a completed package, the assembly operation, and the selection of pieces in the background. The suggested package size has a face width of 6 inches, a length of 96 inches, and contains 8 layers. Each package, therefore, covers 32 square feet, and in red oak weighs

about 50 pounds. The bottom layer in each package should preferably be full-length pieces (one 6-inch width, two 3's, or a 4- and a 2-inch width). The remaining layers can be of any combination of the pieces shown in the background of figure 6. Mathematically, there are several thousand possible combinations of the four widths and four lengths in one layer. Instructions shown in figure 7 for installing the panels would be enclosed in each package.

Yield of Paneling and Flooring Blocks

The yield of merchantable paneling and flooring blocks from low-quality logs depends on many factors including quality, size, and straightness of logs; thickness and width of pieces in the cutting list; type of log breakdown equipment: method of drying; and perhaps most important of all, the amount and location of character marks permitted in the final product. In the grade of paneling made from the red oak logs at the FPL, sound knots, stain, worm holes, and other small openings were permitted on the face. There was no limitation on the defects permitted on the back. Openings entirely through the piece were permitted If they were exceedingly small, perhaps not over 1/8 inch in any dimension. Splits, although they were held together tightly, were not permitted. Paneling intended for flooring use would have fewer defects, with no openings on the face.

The pieces for the flooring blocks also allowed no open defects on the face and only small tight knots. Stain or other discolorations were permitted.

The logs were graded before sawing and their average value delivered to the mill was estimatad at $55 per MBF (thousand board feet) Scribner Decimal C scale. If these logs had been sawed for standard grade lumber, the theoretical value of the lumber would have been $66.20 per MBF. An estimate of the value of railroad ties and side lumber which could have been sawed from the same logs resulted in an average value of $85.05 per MBF. A more detailed explanation of yield is shown in table 1.

The actual yield obtained in the form of paneling and flooring blocks is shown in table 2. Due to limitations in equipment, most of the boards were sawed using a headsaw having a scant 5/16-inch kerf. On the basis that this breakdown operation could be done with a log sash gangsaw having multiple saws with kerf of 1/8 inch or less, a correction factor of 25 percent increase in yield is reasonable. These corrected yield figures are shown at the bottom of table 2.

If an alternative analysis of yield is based on a saw blade thickness of 1/16 inch, a kerf of 1/10 inch, a green board thickness of about 17/32 inch, and a

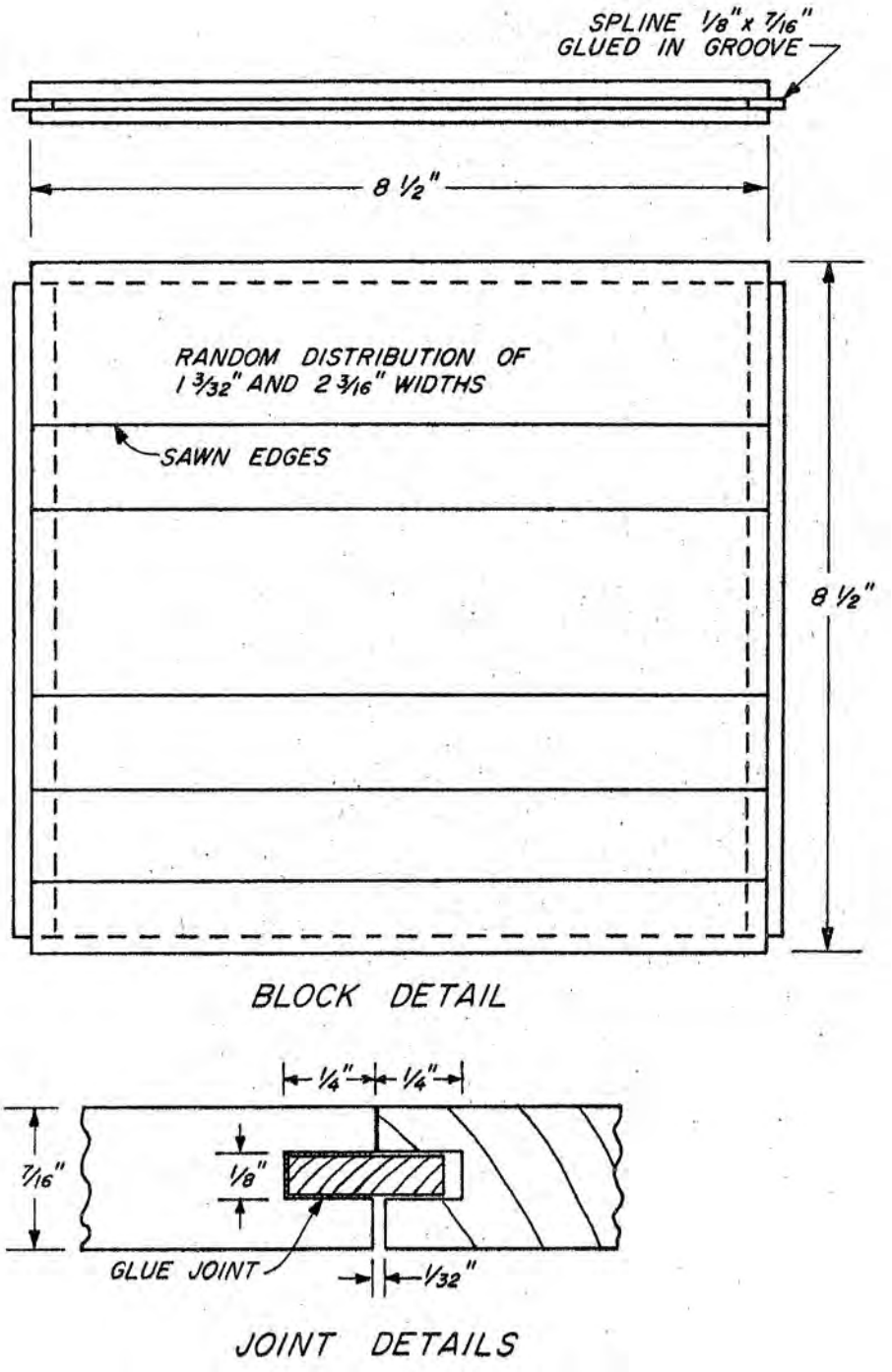

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Figure 5.--Machining and assembly details of flooring block. FPL–0122

Figure 6.--Randomizing and packaging of paneling.

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Table 1.--Grade of red oak logs and estimated[1] grade yields and lumber value compared to value for ties and side lumber

Log No.	Diameter	Grade[2]	Gross scale[3]	Scale deduction	Net scale	Estimated lumber grade yield						Estimated lumber value[4]	Estimated value in ties and side lumber[4]
						FAS	Sel	1C	2C	3A	3B		
			Board feet									Dollars	Dollars
A	12	3	40	2	38	--	--	6	9	7	16	2.67	3.64
B	11	3	30	--	30	--	--	3	6	5	16	1.91	3.00
C	10	3	30	3	27	--	--	6	6	4	11	2.03	2.20
D	10	3	30	--	30	--	--	6	7	5	12	2.21	2.20
E	10	3	30	--	30	--	--	6	7	5	12	2.21	2.20
F	10	2	30	3	27	2	4	8	5	3	5	3.10	2.20
G	10	BG	30	--	30	--	--	--	5	6	19	1.62	2.20
H	10	BG	30	6	24	--	--	--	3	5	16	1.26	2.20
I	10	BG	30	--	30	--	--	--	5	6	19	1.62	2.20
J	9	BG	20	2	18	--	--	--	--	1	17	.83	1.70
K	10	BG	30	9	21	--	--	--	3	5	13	1.13	2.20
L	9	BG	20	--	20	--	--	--	--	1	19	.92	1.70
Total:			350	25	325	2	4	35	56	53	175	21.51	27.64

[1] Grade yields estimated by use of Forest Products Laboratory Report 1737, "Hardwood Log Grades for Standard Lumber," 1959.

[2] BG indicates Below Grade.

[3] Scribner Decimal C Scale.

[4] On basis of hardwood market report for northern red oak lumber, 3/13/65. Price per thousand board feet (f.o.b. mill) was: FAS, $216; Sel, $195; 1C, $139; 2C, $110; 3A, $65; and 3B, $45.

Table 2.--Yield by area of paneling and flooring blocks from 12 red oak logs

Log No.	Panel pieces total sq. in.	Flooring pieces total sq. in.	Grand total sq. in.	Total sq. feet
A	8,736	1,110	9,846	68.38
B	4,960	530	5,490	38.12
C	4,560	780	5,340	37.08
D	3,896	620	4,516	31.36
E	5,600	560	6,160	42.78
F	4,912	360	5,272	36.61
G	5,920	740	6,660	46.25
H	3,424	950	4,374	30.38
I	5,056	960	6,016	41.78
J	3,076	740	3,816	26.50
K	4,017	690	4,707	32.69
L	4,288	930	5,218	36.24
Odd pieces	48	160	208	1.44
Totals	58,493	9,130	67,623	
Totals in sq. ft.	406.20	63.40	469.60	
Totals in sq. ft. increased 25 pct. by adding 1/8-inch saw	507.75	79.25	587.00	

finished product thickness of 3/8 inch, there is an increase in theoretical yield of 14 percent more than shown in table 2. An increase by this percentage over the yield of 587 square feet (table 2) results in 642 square feet, which must be adjusted by a reduction of 4 percent for the change in length modules from 16 to 24 inches. A further reduction factor of 10 percent is applied to allow for natural errors in ripping and crosscutting (because no templates will be used in the industrial operations). Final yield becomes a realistic 578 square feet for the above conditions.

Yield information by weight is presented in summary form in table 3. All boards were planed to final thickness, so the yield figures on a weight basis would probably coincide very closely with the yield figures, which would be obtained on an area basis.

The effect of a change in module length from 16 to 24 inches is shown in table 4. The figures shown are on a square-foot basis and arc calculated from the area of marked-out pieces from two logs. The actual yields for the two modules show a slightly lower total yield for the 24-inch module for the 16-inch. This change in module length was included in an attempt to produce lengths in which the end joints between panel pieces would fall between the studs, so that nailing at the ends would be held to a minimum to avoid splitting. If the joints are on the studs, the end of at least one piece would be nailed.

The effect of the two drying processes (kiln and press) on the amount of shrinkage in thickness and width for logs C and F is presented in table 5. The shrinkage in both thickness and width of the kiln-dried material was between 4.4 and 5.9 percent when dried from the green condition to about 7 percent moisture content. Random distribution of grain angles was the same for both kiln-dried and press-dried material, but in drying from green condition to about 1 percent moisture content the reduction in thickness for press-dried boards was between 12 and 14.6 percent, and the reduction in width only 1.4 to 1.6 percent.

Comparison of dimensional stability of similar kiln-dried and pressed-dried boards when exposed to the same conditions of temperature and relative humidity revealed that the dimensional changes of the press-dried board were about three-fourths as much as the kiln-dried.

Installation of Paneling and Flooring Blocks

The paneling can be installed either horizontally (directly on the studs) or vertically on nailers between studs. The spacing of the supports to which the

Table 3.--Yield by weight of paneling and flooring blocks from 12 red oak logs. (Logs No. 3 or below, 10-inch average diameter, 8-1/2 feet long)

Board group[1]	Gross dry board weight	Paneling		Flooring blocks		Total weight of paneling and floor blocks	Percent total yield
		Net weight	Percent yield	Net weight	Percent yield		
Press-dried	566	295	52	44	8	339	60
Kiln-dried	539	258	48	43	8	301	56

[1]Half of the boards were press-dried; the other half were kiln-dried.

Table 4.--Effect of module length on theoretical yield[1]

Module length	Paneling	Flooring	Total
In.	Sq. ft.	Sq. ft.	Sq. ft.
16	65.77	7.91	73.68
24	60.59	10.14	70.73

[1]Logs C and F only.

Table 5.--Shrinkage of boards in drying

Log designation	Drying method	Average reduction in thickness	Average reduction in width
		Pct.	Pct.
C	Kiln[1]	5.9	4.6
C	Press[2]	14.6	1.6
F	Kiln	5.1	4.4
F	Press	12.0	1.4

[1]See Appendix A for drying details. Final moisture content about 7 percent.
[2]Press conditions--350° F., 50 p.s.i., 55 minutes. Final moisture content about 1 percent.

paneling is nailed is not critical, but if possible the, paneling should be installed so that the end joints do not come on the supports.

The many sizes of paneling pieces permit installation on any size or shape of wall with a minimum of material waste. Installation around electrical outlets. heat ducts, windows, doors, or other wall features is easily performed. In horizontal use, following the instructions shown in figure 7 will result in correct application of the paneling.

A small display panel of the press-dried material, which was slightly darkened in color in the press drying, is installed horizontally as a radiator cover in a Forest Products Laboratory office (fig. 8). This panel, 30 inches high and 8 feet long, is merely hung in place; therefore it can be removed and used for demonstration purposes.

Display panels were also prepared from the 60 square feet of flooring blocks. The panel composed of kiln-dried flooring blocks finished with three coats of sealer plus one coat of wax is shown in figure 9.

Comments, Conclusions, and Recommendations

In fabricating a small amount of material, it is difficult to recommend detailed procedures and sequences to be used in the machining operations. This material was sawn from low-grade logs to make unedged boards, and dried in this condition; then it was planed and finally cut up (ripping first) to the maximum yield of the various-size pieces. Using this procedure, all residue material goes through the drying operations. With some experience, the machine operators can decide which defects can be allowed when viewed in the green rough condition. Perhaps rough edging the boards before drying would be advisable to avoid drying part of this residue. This might be somewhat impracticable, however, because much of the excess material from the paneling operation goes into flooring blocks.

Whether to end match before side matching is another question which can be answered by experience and by using adequate equipment for the fabrication.

The flooring block definitely requires a special assembly machine so that the pieces can be fed into a hopper. As they pass through the machine, they are grooved on the ends, supplied with a spline on each end, and cut off to the rough length. They can then be machined for width and grooved at the same time.

The flooring blocks used in this study were 8-1/2 inches square so that each block represents almost exactly 1/2 square foot. This might be an aid in merchandising as, for example, 100 square feet of floor would require 200 blocks.

Comments on the sample installations of this paneling have been favorable. This is particularly so for the press-dried material which has been changed in color. The success in the marketplace naturally will depend largely on its cost and promotion effort. The waste factor on any size of wall, whether material is laid horizontally or vertically, would be exceedingly small. Labor required in installation would be considerably less than that required for installing wood-strip flooring, and could easily be done by the "do-it-yourselfer."

A green rough thickness of 0.6 inch was found to be adequate for a dry finished thickness of 7/16 inch (0.438 inch) by either drying method. The 7/16-inch finished thickness has ample stiffness to give the impression of boards, and it was judged that the thickness could be further reduced to 3/8 inch without, the paneling becoming weak and limber after installation. This would reduce the green thickness of the boards to about 9/16 inch, or even less with accurate sawing. This reduced thickness might result in more difficulty in molding excessive cup during kiln drying, but should make press drying more practicable.

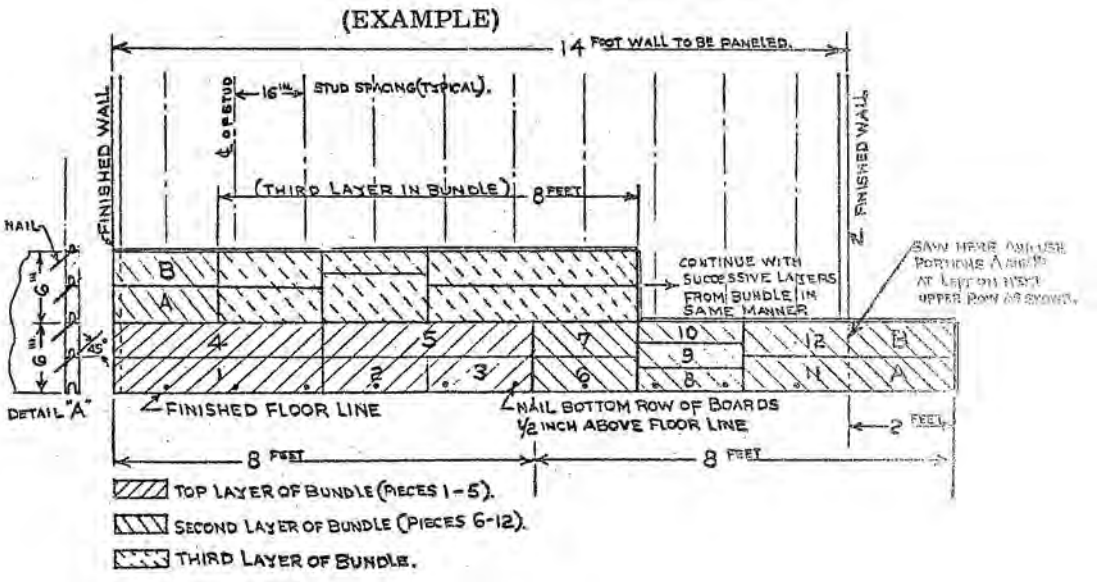
It was found that a 2-foot-length module is better than a 16-inch. This change has several advantages such as:

(1) Makes it almost impossible to have the end joints on the studs (in horizontal application).
(2) Slightly fewer pieces to handle.
(3) Yields more material for the flooring block.

Thought should be given to finding other products, such as drawer sides, which can be obtained from some of the clear cuttings in making paneling.

INSTRUCTIONS FOR INSTALLING HORIZONTAL PANELING

Tools needed to install paneling; rule, saw, hammer, square, and nail set.
Bundle must be opened tog side up.
Remove package of nails from bundle.
Each bundle contains eight layers of board, but the number of boards in each layer varies,
The boards in each Payer must be installed as mating units and never interchanged with board from other layers in the bundle. Always place horizontal tongue on boards on top and vertical tongue to the right.
Always complete the installation of each layer before proceeding to the next layer of boards in the bundle.
At ceiling, rip the top boards to fit; also, face nail to suit molding.
Each layer in bundle covers an mea 6 inches high by 8 feet long. Entire bundle covers 32 square feet of wall area.
Individual board sizes included in bundle vary to obtain a variety of patterns. Lengths of boards are 24, 48, 72, or 96 inches; heights of boards are 2, 3, 4, or 6 inches.



NOTE: Nail individual boards to studs at tongue as shown. Use nail set to countersink mail head. See detail "A."

Numbers shown indicate sequence of installing individual boards comprising each layer of bundle. In paneling wall, always start at finished floor line as shown.

Figure 7.--Instructions for installing horizontal panelling.

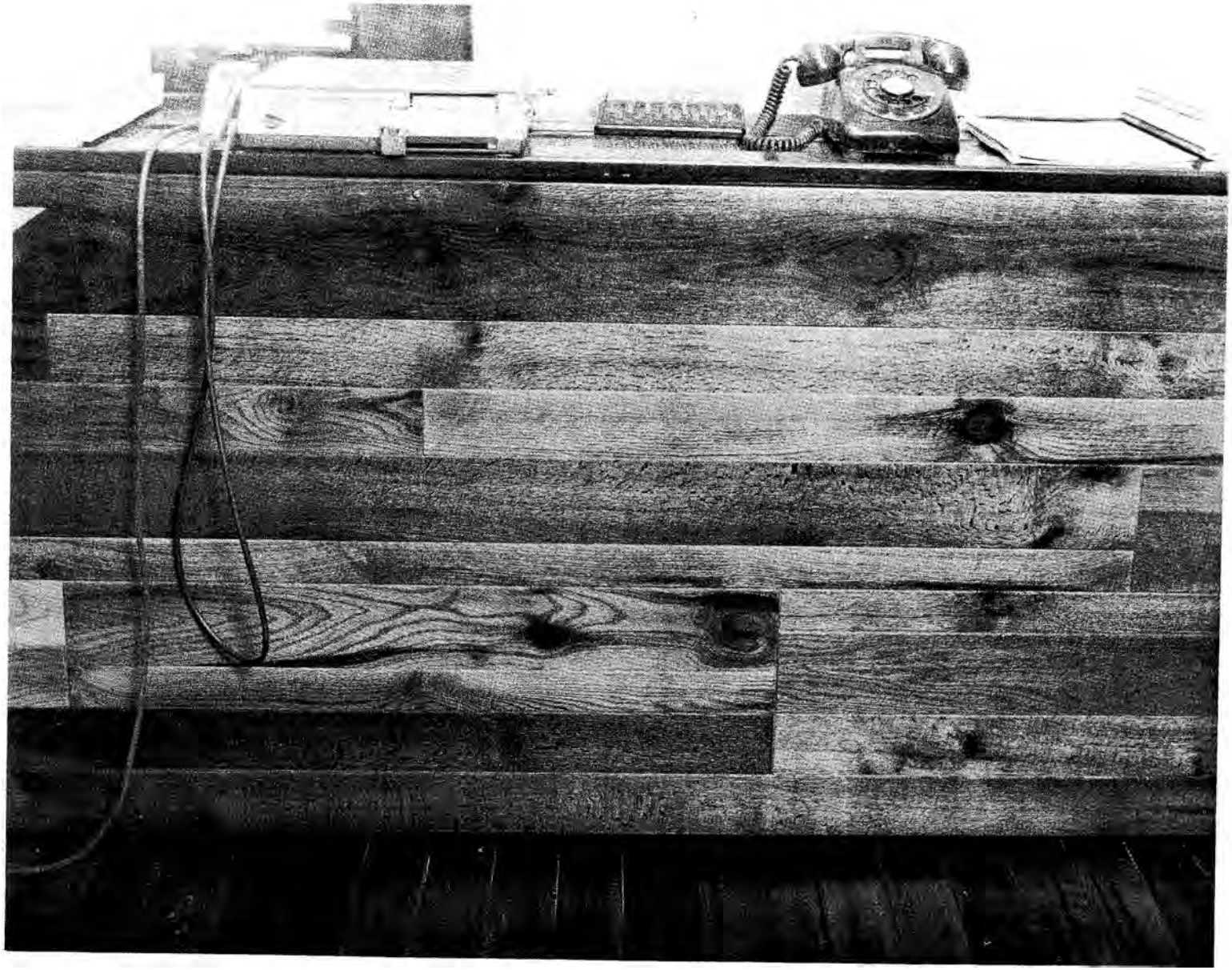


Figure 8.--Typical panel of press-dried material.

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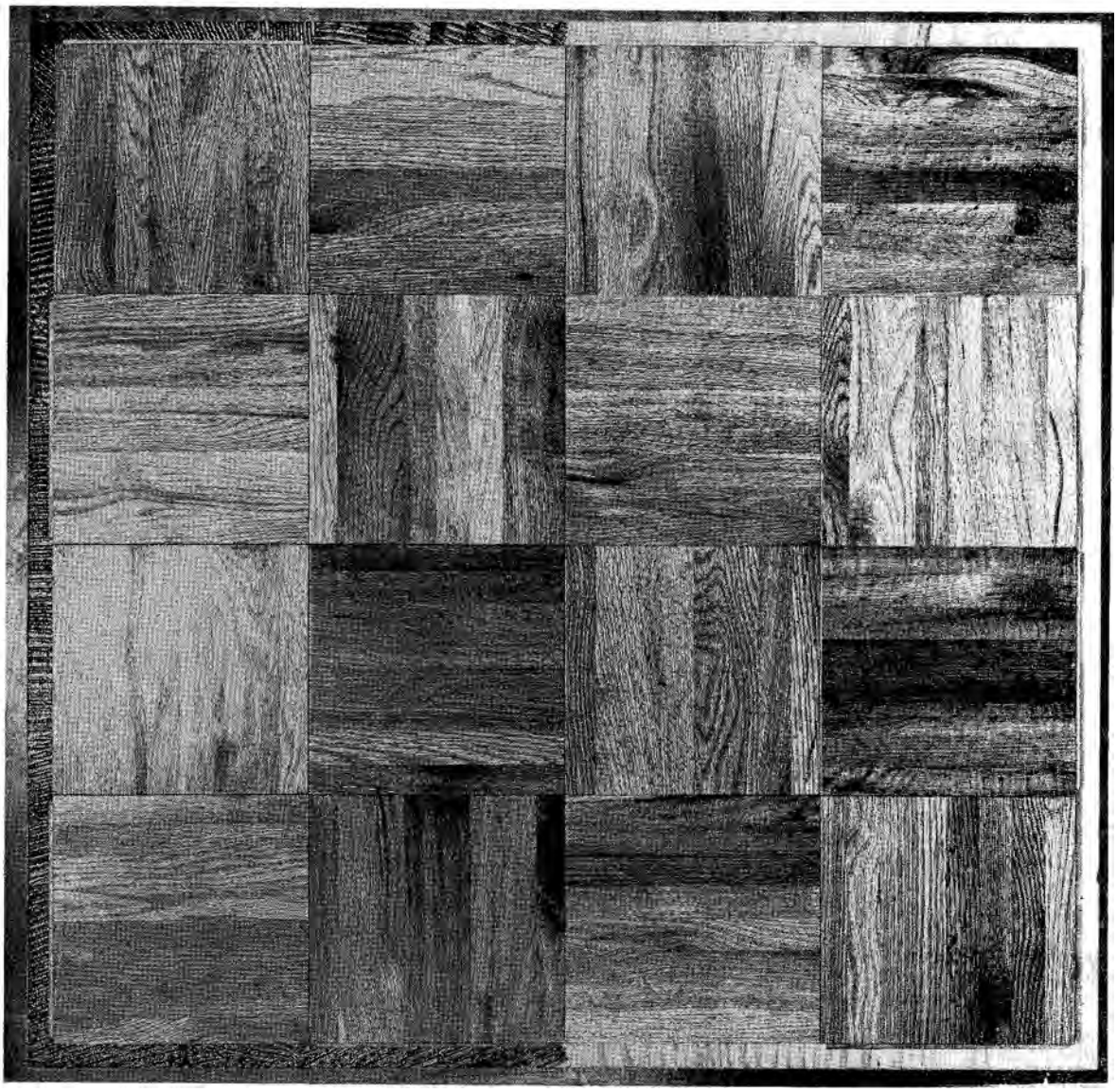

Figure 9.--Typical flooring block panel of press-dried material.

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APPENDIX A--CONVENTIONAL DRYING

Approximately 300 surface feet of 5/8-inch, live-sawn, unedged, random-width red oak boards were dried by a conventional method consisting of 7 days of forced-air drying and 6-1/2 days of kiln drying, equalizing, and conditioning. The selection of these procedures was based on general knowledge that preliminary air drying followed by kiln drying gives the flattest stock, and that forced-air drying is capable of year-around production with essentially the same results as 2 to 4 times as much air drying under the most favorable conditions.

The total time for forced-air drying was arbitrarily set at 7 days, using the schedule shown in figure 10. The kiln schedule for 4/4 red oak, shown also in figure 10, was used for the kiln portion. Eight kiln samples were used; equalizing was started at the end of the 11th day and conditioning at the end of the 13th. Total conditioning time was arbitrarily set at 12 hours, with an interruption for moisture and stress tests at the end of the first 8 hours.

Both forced-air and kiln drying were done in a small experimental internal-fan kiln with air circulation through the load about 300 feet per minute. The lumber was carefully piled with 2-foot sticker spacing and vertical sticker alinement.

Drying conditions and kiln sample moisture results are given in table 6 and illustrated in figure 10. The stock was bright in color in the rough and after planing. There were no surface, end, or honeycomb checks from the drying operation. The stock was generally flat, with only a few boards having slight cup.

The first 8 hours of conditioning relieved drying stresses (casehardening) in the kiln samples; in fact, there was a slight reversal of stresses. Since the immediate test for residual stresses is not conclusive because of moisture gradients, conditioning was resumed. The kiln was shut off after 4 more hours of conditioning, and the stock was left in the kiln for cooling for 12 more hours. Such cooling in the kiln is not necsasary for commercial production.

The final stress tests on tho samples showed that a new stress-and-set condition had developed similar to what probably existed when conditioning was started. Whether this final "casehardening" in the samples was due to drying during intermediate moisture content determination and reweighing after the initial stress determination, or to the additional 4 hours of conditioning, is not known. If the same condition prevailed in the stock that was made into paneling and flooring, it could have augumented the planer stresses and promoted splitting.

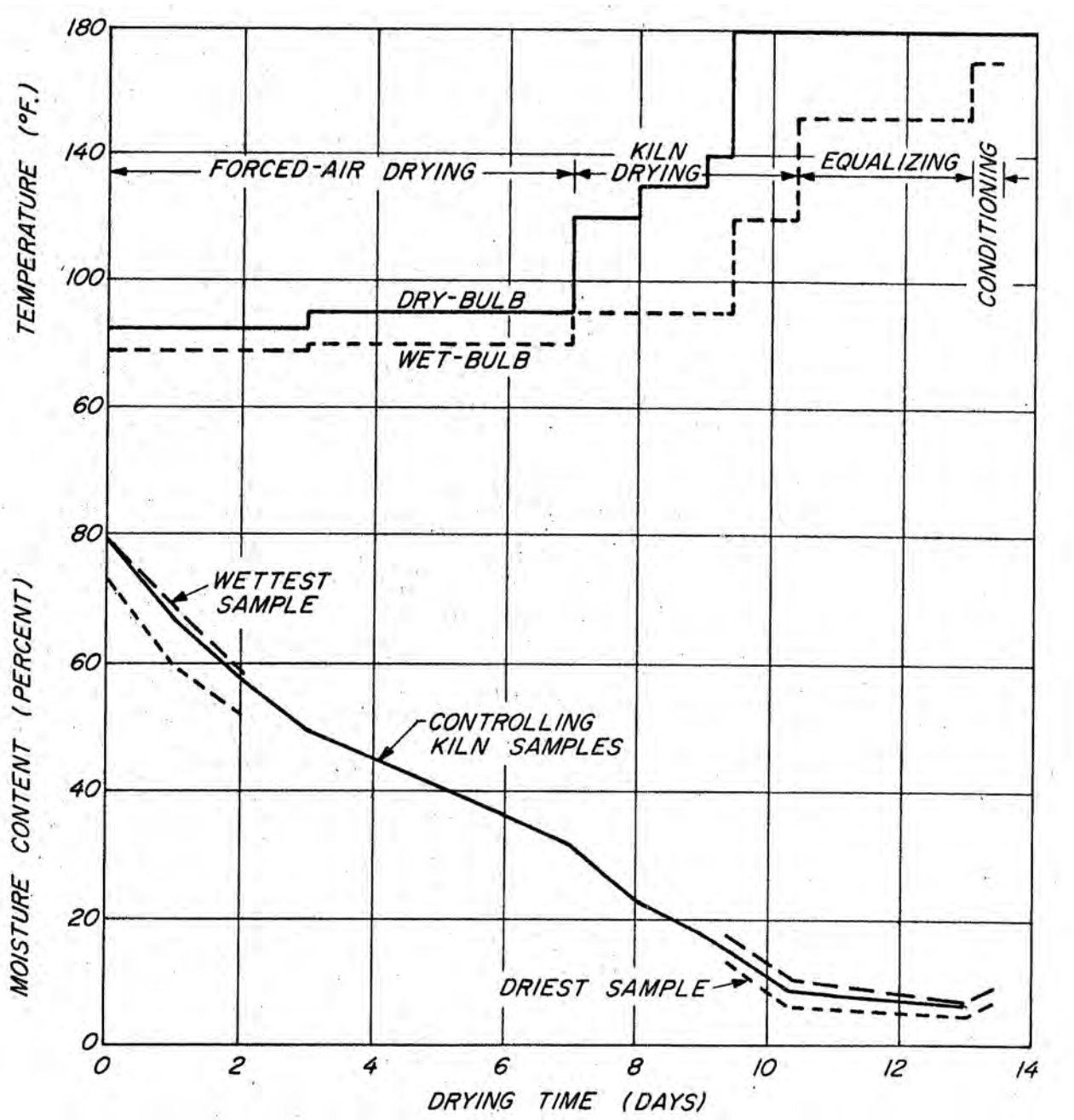

Figure 10.––Drying conditions and kiln sample moisture content of 5/8–inch red oak dried by conventional methods for paneling and flooring.

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Initial moisture content of the kiln samples averaged 77 percent, with the minimum 73 percent and the maximum 79 percent. Final average moisture content, by oven test from the: kiln samples, was 6.9 percent, with the minimum 6.8 percent and maximum 7.2 percent. At the end of 8 hours of conditioning the values were about 0.2 percent higher.

The drying conditions used here are not known to be optimum for forced–air and kiln–drying operations. The forced–air portion should be reasonably satisfactory, although slightly faster drying may have been obtainable with wet–bulb depressions of 10° F, for forced–air drying and 14° F, for kiln drying, Minor temperature variations in the range of 70° to 100° F. should not greatly affect drying time to 30 percent moisture content. In commercial forced–air dryers, the results achieved in this study should be obtainable in 8 or 9 days. Kiln drying from 30 to 7 percent moisture content using more severe conventional kiln schedules and equalizing and conditioning to acceptable industry standards probably could have been accomplished in 4 days in experimental equipment and 5 days commercially. If a satisfactory procedure could be worked out, the elevated temperature kiln–drying process could probably dry 5/8–inch red oak from the green condition in 2-1/3 days.

Table 6.--Drying conditions and moisture content for 5/8-inch red oak for paneling and flooring

Period	Time	Conditions		Moisture content[1]		
		Dry-bulb temperature	Wet-bulb depression	Wettest sample	Driest sample	Average of all samples
	Days	°F.	°F.	Pct.	Pct.	Pct.
Forced-air drying	0 - 3	85	7	79	73	77
	3 - 7	90	10	50	45	48
Kiln drying	7 - 8	120	30	33	29	31
	8 - 9	130	40	24	20	22
	9 - 9-1/3	140	50	19	15	16
	9-1/3 - 10-1/3	180	60	18	13	15
Equalizing	10-1/3 - 13	180	28	10	6	8
Conditioning	13 - 13-1/3	180	10	4	7	6
	13-1/3 - 13-1/2	180	10	6	9	8
Final				6	7	6.5

[1] Of kiln samples at start of each period, based on original moisture content determination, except for final values based on oven tests after 8 hours of conditioning.

APPENDIX B--PRESS DRYING

Seventy-nine red oak boards approximately 0.6 inch thick were press dried for this study. The drying conditions were varied over a wide range, but were limited to two press temperatures--300° and 350° F. A drying curve for each temperature was developed for several boards, and figure 11 shows the average drying curves for seven boards at each of the two temperatures. To obtain the drying curves, it was necessary to remove the boards from the press for immediate weighing, which took about 3 minutes for each weighing. During this time the boards, being hot, were probably drying somewhat; therefore, a continuous cycle in the press for 50 minutes, for example, may not yield the same results as 50 minutes net time when the boards were removed several times for weighing.

The pressure on the boards was varied over a range from 50 p.s.i. to 100 p.s.i. No significant differences were noted in the restraint; therefore, most of the later drying tests were made at 50 p.s.i.

After an approximate drying curve was established, it was possible to estimate the time required in the press to yield an average moisture content of about 8 percent. This was done with several boards and they were checked with a moisture meter to determine the moisture gradient. It was found that the surface of the boards was almost ovendry, whereas the moisture content indicated for the center was about 16 percent. After the moisture in these boards had diffused and become more or less equal throughout the thickness, there was a marked tendency for the boards to cup, check, and in some places collapse.

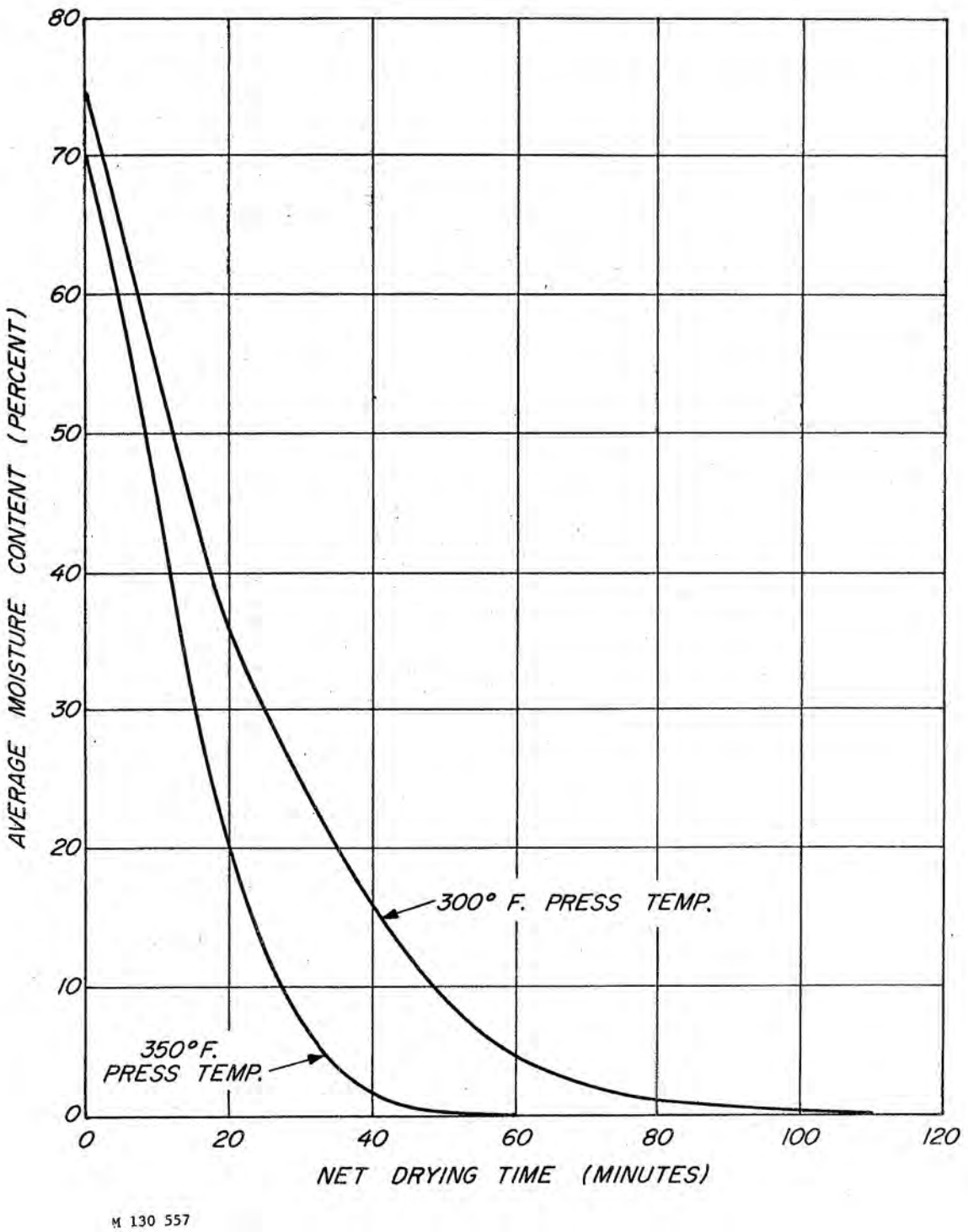

Figure 11.--Drying rate curves for red oak boards dried at 300° and 350° F. in a hot press board thickness of 0.60 inch.

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